This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (original) A method of manufacturing a hearing-aid shell, comprising the steps of:

nonuniformly thickening a three-dimensional digital model of a shell surface about a directed path thereon to define a thickened model; and

generating an undersurface hearing-aid vent in the thickened model of the shell surface, at a location proximate the directed path.

2. (original) The method of Claim 1, wherein the digital model of the shell surface is a 2-manifold or 2-manifold with nonzero boundary; and wherein the thickened model of the shell surface is a watertight model that is free of self-intersections.

3. (currently amended) The method of Claim 1, further comprising the step of uniformly thickening the digital model of the shell surface relative to the partially offset inner shell surface to determine an entirely offset inner shell surface, and wherein said nonuniformly thickening step comprises the step[[s]] of[[:]] nonuniformly thickening the digital model of the shell surface about the directed path to determine a partially offset inner shell surface.[[;]] ~~and uniformly thickening the digital model of the shell surface relative to the partially offset inner shell surface to determine an entirely offset inner shell surface.~~

4. (original) The method of Claim 1, wherein said nonuniformly thickening step comprises the steps of:

nonuniformly thickening the digital model of the shell surface about the directed path to determine a partially offset inner shell surface; and

nonuniformly thickening the digital model of the shell surface having the partially offset inner shell surface to determine an entirely offset inner shell surface.

5. (original) The method of Claim 3, wherein said nonuniformly thickening step comprises thickening the digital model of the shell surface using a bump function constructed around a kernel defined by the directed path.

6. (original) The method of Claim 5, wherein said nonuniformly thickening step comprises the steps of:

determining a first offset of the directed path normal to the shell surface; and

determining a respective normalized adjusted normal for each of a plurality of vertices on the directed path using parametrizations proportional to a distance between the directed path and the first offset of the directed path.

7. (currently amended) The method of Claim 6, wherein said nonuniformly thickening step comprises determining a respective normalized adjusted normal for each of [[a]] the plurality of first vertices on the digital model of the shell surface that are within a support of the bump function, by mixing an estimated normal at the respective first vertex with the normalized adjusted normal at a nearest vertex on the directed path.

8. (original) The method of Claim 7, wherein the digital model of the shell surface is a surface triangulation that

includes the plurality of first vertices; and wherein the directed path includes at least one vertex that is not a vertex of the surface triangulation.

9. (original) The method of Claim 7, wherein said nonuniformly thickening step comprises locally thickening the digital model of the shell surface by moving a first vertex on the digital model of the shell surface along a respective normalized adjusted normal at the first vertex.

10. (original) The method of Claim 9, wherein the first vertex is moved a distance defined by the bump function.

11. (original) The method of Claim 2, wherein said nonuniformly thickening step comprises the steps of:

uniformly thickening the digital model of the shell surface to determine an entirely offset inner shell surface; and then

nonuniformly thickening the digital model of the shell surface about the directed path.

12. (original) The method of Claim 1, wherein said generating step comprises the steps of:

determining an axis of the vent in the thickened model of the shell surface; and

determining a surface of the vent about the axis.

13. (original) The method of Claim 12, wherein the digital model of the shell surface is a 2-manifold with nonzero boundary; wherein the directed path includes beginning and termination points on the digital model of the shell surface; and wherein the axis of the vent is offset from the directed path adjacent the beginning point and meets the directed path adjacent the termination point.

14. (original) The method of Claim 12, wherein the surface of the vent is a triangulation.

15. (original) The method of Claim 14, wherein the thickened model of the shell surface has a nonuniformly thick rim; and wherein the surface of the vent intersects the thickened model of the shell surface at a thickest part of the rim.

16. (original) The method of Claim 1, wherein said generating step comprises the steps of:

determining an axis of the vent in the thickened model of the shell surface;

determining for each of a plurality of points on the axis, a respective plane that is normal to the axis and passes through the respective point; and

determining for each plane a respective circle having a center on the axis.

17. (original) The method of Claim 16, further comprising the steps of:

tilting a first plurality of the planes to reduce interferences; and

projecting each circle associated with the first plurality of tilted planes as an ellipse on the respective tilted plane.

18. (original) The method of Claim 17, further comprising the step of determining a surface of the vent by connecting the ellipses on the first plurality of tilted planes.

19. (original) The method of Claim 18, wherein the digital model of the shell surface is a 2-manifold with

nonzero boundary; wherein the directed path includes beginning and termination points on the digital model of the shell surface; and wherein the axis of the vent is offset from the directed path adjacent the beginning point and meets the directed path adjacent the termination point.

20. (original) The method of Claim 19, wherein the surface of the vent is a triangulation.

21. (original) The method of Claim 20, wherein the thickened model of the shell surface has a nonuniformly thick rim; and wherein the surface of the vent intersects the thickened model of the shell surface at a thickest part of the rim.

22. (original) A method of manufacturing a hearing-aid shell, comprising the steps of:

generating a three-dimensional digital model of a hearing-aid shell surface from point cloud data;

automatically nonuniformly thickening the digital model about a directed path that identifies a desired location of an undersurface hearing-aid vent, to determine a thickened model having an entirely offset inner shell surface; and

generating the vent in the thickened model, at a location proximate the directed path.

23. (original) The method of Claim 22, wherein the thickened model is a watertight model that is free of self-intersections.

24. (original) The method of Claim 22, wherein said generating step is preceded by the step of generating point cloud data by scanning an imprint of an ear canal of a user.

25. (currently amended) The method of Claim 23, wherein said step of generating [[a]] the vent is followed by the step of printing a hearing-aid shell having a nonuniform thickness and a vent extending therethrough, based on the thickened model.

26. (original) A method of manufacturing a hearing-aid shell, comprising the step of: generating a watertight model of a hearing-aid shell by nonuniformly thickening a digital model of a hearing-aid shell surface about a portion of the shell surface that defines a desired location of an undersurface hearing-aid vent.

27. (currently amended) The method of Claim 26. wherein said step of generating [[a]] the watertight model comprises nonuniformly thickening the digital model using a bump function constructed around a kernel defined by a set of points on the shell surface.

28. (original) The method of Claim 27, wherein the bump function is derived from a Gaussian distribution function or a spline function.

29. (original) The method of Claim 26, wherein said step of generating a watertight model is preceded by the steps of:

generating a volume triangulation from point cloud data describing a shape of an ear canal of a subject;

generating a first surface triangulation that is a 2-manifold from the volume triangulation; and

generating a second surface triangulation that is a 2-manifold with nonzero boundary from the first surface triangulation by cutting the first triangulation along a plane.

30. (currently amended) The method of Claim 29 further comprising the step of generating [[a]] the hearing-aid vent in the thickened model by:

determining an axis of the hearing-aid vent in the thickened model; and

determining a surface of the hearing-aid vent about the axis.

31. (original) The method of Claim 26, further comprising the step of generating the hearing-aid vent in the thickened model by:

determining an axis of the hearing-aid vent in the thickened model; and

determining a surface of the hearing-aid vent about the axis.

32. (original) A method of manufacturing a hearing-aid shell, comprising the steps of:

generating a surface triangulation of the hearing-aid shell from point cloud data describing a shape of at least a portion of an ear canal of a subject;

generating a watertight 2-manifold triangulation of the hearing-aid shell from the surface triangulation;

generating a 2-manifold with nonzero boundary triangulation of the vent that is compatible with the watertight 2-manifold triangulation of the hearing aid shell; and

printing a three-dimensional hearing-aid shell based on the watertight 2-manifold triangulation of the hearing-aid shell and the 2-manifold with nonzero boundary vent triangulation.

33. (original) The method of Claim 32, further comprising

the steps of: generating a 2-manifold with nonzero boundary triangulation of the hearing-aid shell from the watertight 2-manifold triangulation of the hearing aid shell, by defining vent holes therein; and merging the 2-manifold with nonzero boundary triangulation of the vent and the 2-manifold with nonzero boundary triangulation of the hearing-aid shell to define a watertight 2-manifold triangulation of the hearing-aid shell having a vent therein.

34. (original) A method of manufacturing a hearing-aid shell, comprising the step of: thickening a three-dimensional digital model of a hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface along a respective path that is normal to an inner shell surface.

35. (original) The method of Claim 34, wherein the digital model of the hearing-aid shell surface is thickened sufficiently to support formation of a hearing-aid vent in a wall thereof upon printing of the thickened digital model.

36. (original) The method of Claim 34, wherein the thickened digital model of the hearing-aid shell is a watertight digital model that is free of self-intersections.

37. (original) The method of Claim 34, wherein said thickening step comprises:

nonuniformly thickening the three-dimensional digital model of the hearing-aid shell surface about a directed path that identifies a desired location of an undersurface hearing-aid vent, to determine a partially offset inner shell surface; and

uniformly thickening the three-dimensional digital model of the hearing-aid shell surface relative to the

partially offset inner shell surface to determine an entirely offset inner shell surface.

38. (original) The method of Claim 34, wherein said thickening step comprises:

nonuniformly thickening the three-dimensional digital model of the hearing-aid shell surface to determine a partially offset inner shell surface; and

nonuniformly thickening the three-dimensional digital model of the hearing-aid shell surface having the partially offset inner shell surface to determine an entirely offset inner shell surface.

39. (currently amended) The method of Claim 34, wherein the three-dimensional digital model of [[a]] the hearing-aid shell surface is a surface triangulation; and wherein said thickening step is followed by the step of printing the hearing-aid shell based on the thickened digital model.

40. (original) An automated hearing-aid shell manufacturing system, comprising:

a computer-readable storage medium having computer-readable program code embodied in said medium, said computer-readable program code comprising:

computer-readable program code that generates a first digital model of a hearing-aid shell from point cloud data; and computer-readable program code that determines whether first internal hearing-aid components can fit properly within an interior volume of the first digital model of the hearing-aid shell.

41. (original) The manufacturing system of Claim 40, wherein said computer-readable program code further comprises:

computer-readable program code that generates a second digital model of a hearing-aid shell that is larger than the first digital model, from the point cloud data; and

computer-readable program code that determines whether the first internal hearing-aid components can fit properly within an interior volume of the second digital model of the hearing-aid shell.

42. (original) The manufacturing system of Claim 41, wherein the first digital model is a completely-in-ear-canal (CIC) digital model and the second digital model is an in-the-ear (ITE) digital model.

43. (original) An automated hearing-aid shell manufacturing system, comprising:

a scanning tool that generates point cloud data describing a shape of at least a portion of an ear canal of a subject, from the ear canal of the subject or an impression of the ear canal of the subject; and

a computer-readable storage medium having computer-readable program code embodied in said medium, said computer-readable program code comprising: computer-readable program code that generates a digital model of a hearing-aid shell from the point cloud data; and

computer-readable program code that determines whether size specifications of internal hearing-aid components are compatible with an interior volume of the digital model of the hearing-aid shell.

44. (original) The manufacturing system of Claim 43, wherein said computer-readable storage medium comprises

computer-readable program code that determines whether size specifications of internal hearing-aid components loaded from an internet site or electronic file are compatible with an interior volume of the digital model of the hearing-aid shell.

45. (original) The manufacturing system of Claim 43, wherein said computer-readable storage medium comprises computer-readable program code that generates a digital model of a hearing-aid shell surface as a 2-manifold with nonzero boundary from the point cloud data and nonuniformly thickens the shell surface about a directed path that identifies a desired location of an undersurface hearing-aid vent.

46. (original) The manufacturing system of Claim 45, wherein the point cloud data is a 2-manifold triangulation or 2-manifold with nonzero boundary triangulation; and wherein said computer-readable storage medium comprises computer-readable program code that generates a digital model of a vent in the nonuniformly thickened shell surface at a location proximate the directed path.

47. (original) The manufacturing system of Claim 43. wherein said computer-readable storage medium comprises computer-readable program code that generates a digital model of a hearing-aid shell surface as a 2-manifold with nonzero boundary from the point cloud data and thickens the shell surface using operations that move each of a plurality of vertices on the shell surface along a respective path that is normal to an inner shell surface.

48. (original) The manufacturing system of Claim 47, wherein said computer-readable storage medium comprises computer-readable program code that generates a digital model of a vent in the thickened shell surface.

49. (original) The manufacturing system of Claim 48, wherein said computer-readable storage medium comprises computer-readable program code that determines whether size specifications of internal hearing-aid components loaded from an internet site or electronic file are compatible with an interior volume of the digital model of the hearing-aid shell.

50. (original) A method of generating a digital model of a hearing-aid shell, comprising the step of: generating a three-dimensional model of a hearing-aid shell surface by modifying a shape of a first digital model of a positive or negative representation of at least a portion of an ear canal of a subject to more closely conform to a shape of a digital template of a hearing-aid shell and/or modifying the shape of the digital template to more closely conform to the shape of the first digital model.

51. (original) The method of Claim 50, wherein said generating step is preceded by the steps of:

generating point cloud data describing a shape of at least a portion of an ear canal of a subject by scanning either the ear canal of the subject or an impression of the ear canal of the subject;

generating a volume triangulation from the point cloud data; and

generating the first digital model as a surface triangulation that is a 2-manifold or 2-manifold with nonzero boundary.

52. (original) The method of Claim 50, further comprising the step of: nonuniformly thickening the three-dimensional model of the hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface

along a respective path that is normal to an inner shell surface.

53. (original) A method of manufacturing a hearing-aid shell, comprising the steps of:

generating a first digital representation of a positive or negative image of at least a portion of an ear canal of a subject;

generating a second digital representation of a hearing-aid shell that has a shape that conforms to the ear canal of the subject; and

printing a hearing-aid shell that conforms to the ear canal of the subject, based on the second digital representation.

54. (original) The method of Claim 53, wherein the first digital representation is a representation selected from the group consisting of a point cloud representation, a 2-manifold triangulation and a 2-manifold with nonzero boundary triangulation.

55. (original) The method of Claim 53, wherein said step of generating a second digital representation comprises the step of modifying a shape of the first digital representation to more closely conform to a shape of a digital template of a hearing-aid shell and/or modifying the shape of the digital template to more closely conform to the shape of the first digital representation.

56. (original) The method of Claim 53, wherein said step of generating a second digital representation comprises the steps of: generating a three-dimensional model of a hearing-aid shell surface that is a 2-manifold or 2-manifold with nonzero boundary; and thickening the three-dimensional model

of the hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface along a respective path that is normal to an inner shell surface.

57. (original) The method of Claim 53, wherein said step of generating a second digital representation comprises the steps of: generating a three-dimensional model of a hearing-aid shell surface that is a 2-manifold or 2-manifold with nonzero boundary; and nonuniformly thickening the three-dimensional model of the hearing-aid shell surface about a directed path thereon to define a thickened model.

58. (original) The method of Claim 57, further comprising the step of generating an undersurface hearing-aid vent in the thickened model of the shell surface, at a location proximate the directed path.

59. (currently amended) The method of Claim 58, further comprising the step of uniformly thickening the three-dimensional model of the shell surface relative to the partially offset inner shell surface to determine an entirely offset inner shell surface, and wherein said nonuniformly thickening step comprises the step[[s]] of[[:]] nonuniformly thickening the three-dimensional model of the hearing-aid shell surface about the directed path to determine a partially offset inner shell surface.~~; and~~

~~uniformly thickening the three-dimensional model of the shell surface relative to the partially offset inner shell surface to determine an entirely offset inner shell surface.~~

60. (original) An automated hearing-aid shell manufacturing system, comprising:

a scanning tool that generates point cloud data describing a shape of at least a portion of an ear canal of a subject, from the ear canal of the subject or an impression of the ear canal of the subject; and

a computer-aided design tool that is communicatively coupled to said scanning tool, said computer-aided design tool comprising:

a display; and

a computer system communicatively coupled to said display, said computer system comprising a processor and a computer program product readable by the processor and tangibly embodying a program of instructions executable by the processor to perform the method steps of:

generating a first digital model of at least a portion of the ear canal of the subject from the point cloud data;

aligning a digital template of a hearing-aid shell with the first digital model; and

generating a three-dimensional model of a hearing-aid shell surface by modifying a shape of the digital template to more closely conform to a shape of the first digital model and/or modifying the shape of the first digital model to more closely conform to the shape of the digital template.

61. (currently amended) **T**he manufacturing system of Claim 60, wherein the three-dimensional model of [[a]] the hearing-aid shell surface is a 2-manifold triangulation or a 2-manifold with nonzero boundary triangulation; and wherein said

generating step is followed by the step of thickening the three-dimensional model of a hearing-aid shell surface by moving each of a plurality of vertices on the shell surface along a respective path that is normal to an inner shell surface.

62. (currently amended) The manufacturing system of Claim 61, wherein said thickening step comprises nonuniformly thickening the three-dimensional model of [[a]] the hearing-aid shell surface about a directed path thereon that identifies a desired location of an undersurface vent.

63. (currently amended) The manufacturing system of Claim 62, wherein said nonuniformly thickening step comprises nonuniformly thickening the three-dimensional model of [[a]] the hearing-aid shell surface using a bump function constructed around a kernel defined by the directed path.

64. (currently amended) The manufacturing system of Claim 63, wherein said nonuniformly thickening step is followed by the steps of:

aligning a digital model of a frame to the thickened three-dimensional model of [[a]] the hearing-aid shell surface; and

modifying a shape of the thickened three-dimensional model of a hearing-aid shell surface to be matingly compatible with the digital model of the frame.

65. (currently amended) The manufacturing system of Claim 63, wherein said nonuniformly thickening step is followed by the steps of:

attaching a digital faceplate model to the thickened three-dimensional model of [[a]] the hearing-aid shell surface; and

trimming away portions of the digital faceplate model that are outside an area of intersection between the digital faceplate model and the thickened three-dimensional model of a hearing-aid shell surface.

66. (original) The manufacturing system of Claim 65, wherein said trimming step is followed by the step of: digitally smoothing edges of the digital faceplate model.

67. (currently amended) The manufacturing system of Claim 66, further comprising: a three-dimensional printer that is communicatively coupled to said computer-aided design tool and prints the thickened three-dimensional model of [[a]] the hearing-aid shell surface and digital faceplate model attached thereto, in response to a command from said computer-aided design tool.

68. (currently amended) The manufacturing system of Claim 64, further comprising: a three-dimensional printer that is communicatively coupled to said computer-aided design tool and prints the modified shape of the thickened three-dimensional model of [[a]] the hearing-aid shell surface in response to a command from said computer-aided design tool.

69. (currently amended) The manufacturing system of Claim 60, wherein the digital template of [[a]] the hearing-aid shell has an outer surface and an inner surface spaced from the outer surface.

70. (currently amended) The manufacturing system of Claim 69, wherein the digital template of [[a]] the hearing-aid shell is a watertight model that is free of self-intersections.

71. (currently amended) The manufacturing system of Claim 70, wherein the digital template of [[a]] the hearing-aid shell is a 2-manifold triangulation having a vent therein.

72. (currently amended) A method of generating a digital model of a hearing-aid shell, comprising the step of:

generating a first three-dimensional digital model of a hearing-aid shell; printing [[a]] the hearing-aid shell based on the first three-dimensional digital model;

generating point cloud data by scanning the printed hearing-aid shell; and

generating a second three-dimensional digital model of a hearing-aid shell surface from the point cloud data.

73. (currently amended) The method of Claim 72, further comprising the step of: digitally comparing the second three-dimensional digital model of [[a]] the hearing-aid shell surface against at least a portion of a first three-dimensional digital model of a hearing-aid shell to detect differences therebetween.

74. (currently amended) The method of Claim 72, wherein said step of generating a first three-dimensional digital model is preceded by the step of generating an initial three-dimensional digital model of [[a]] the hearing-aid shell surface by modifying a shape of a first digital model of a positive or negative representation of at least a portion of an ear canal of a subject to more closely conform to a shape of a digital template of a hearing-aid shell and/or modifying the shape of the digital template to more closely conform to the shape of the first digital model.

75. (currently amended) The method of Claim 74, further comprising the step of: digitally comparing the second three-dimensional model of [[a]] the hearing-aid shell surface against the initial three-dimensional model of a hearing-aid shell surface to detect differences therebetween.

76. (original) A method of generating a three-dimensional digital model of a hearing-aid shell, comprising the steps of:

generating an intermediate model of a hearing-aid shell having a partially offset inner surface by locally thickening a three-dimensional model of a hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface along a respective path that is defined by a respective normalized adjusted normal to the shell surface; and then

globally or locally thickening the intermediate model to define an entirely offset inner surface of a thickened model of the shell surface, using operations that move each of a plurality of vertices on the partially offset inner surface along a respective path that is defined by a respective normalized readjusted normal to the partially offset inner surface.

77. (currently amended) The method of Claim 76, wherein said locally thickening step comprises locally thickening a three-dimensional model of [[a]] the hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface that are within a support of a bump function along a respective path that is defined by a respective normalized adjusted normal.

78. (currently amended) The method of Claim 77, wherein said locally thickening step is preceded by the step of designating a location of an undersurface hearing-aid vent on the shell surface; and wherein said locally thickening step comprises locally thickening a three-dimensional model of [[a]] the hearing-aid shell surface using operations that move each of a plurality of vertices on the shell surface a distance no less than about 2r+2w-s, where r designates a radius of the vent, w designates a wall thickness and s designates a shell thickness.

79. (original) The method of Claim 78, wherein said step of globally or locally thickening the intermediate model is followed by the step of repairing self-intersections on the entirely offset inner surface.

80. (original) The method of Claim 79, further comprising the step of generating an undersurface hearing-aid vent in the thickened model of the shell surface.